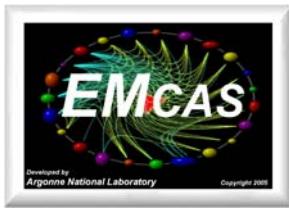


## Modeling and Simulation of Energy Markets

# Electricity Market Complex Adaptive System (EMCAS)



Version 1.7  
May 2006



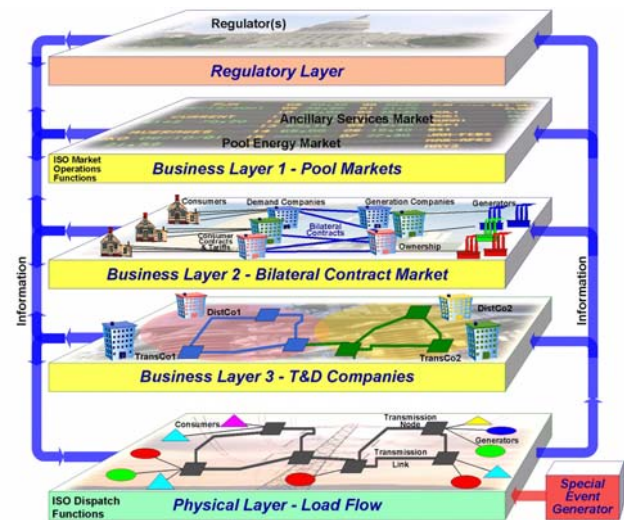
# Electricity Market Complex Adaptive System (EMCAS)

*EMCAS is the latest and most advanced tool in Argonne's suite of power systems analysis software*

## Description

EMCAS uses a novel agent-based modeling approach to simulate the operation of today's complex power systems. EMCAS can be used as an "electronic-laboratory" to probe the possible operational and economic impacts on the power system of various external events. Market participants are represented as "agents" with their own set of objectives, decision-making rules, and behavioral patterns. Agents are modeled as independent entities that make decisions and take actions using limited and/or uncertain information available to them, similar to how organizations and individuals operate in the real world. EMCAS includes all the entities participating in power markets, including consumers, generation companies (GenCos), Transmission Companies (TransCos), Distribution Companies (DisCos), Demand Companies (DemCos), Independent System Operators (ISO) or Regional Transmission Organizations (RTO), and regulators.

All the entities, or agents, interact on several different layers. In the physical layer, the transmission grid is represented on a detailed bus and branch level to allow a full-scale load flow analysis. Here, the system operator dispatches the available generators to meet the load while maintaining the constraints and limitations of the transmission system. If needed, this representation can be simplified by developing a "reduced" transmission network. Several business layers are used to model the various forward markets (e.g., pool energy markets, bilateral contract market) where generation companies can buy and sell power. The operation of the transmission and distribution companies is included in a separate business layer. On the regulatory layer the user can set various operational and markets rules.



EMCAS simulates the operation of a power system and computes electricity prices for each hour and each location in the transmission network. Electricity prices are driven by demand for electricity, cost of electricity production, the extent of transmission congestion, external random or non-random events, such as unit outages or system disruptions, and company strategies. Model results include the economic impacts on individual companies and consumer groups under various scenarios.

## Model and Data Interfaces

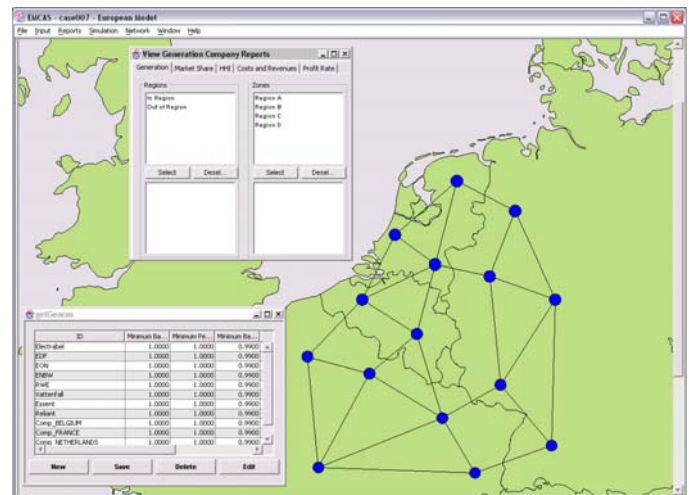
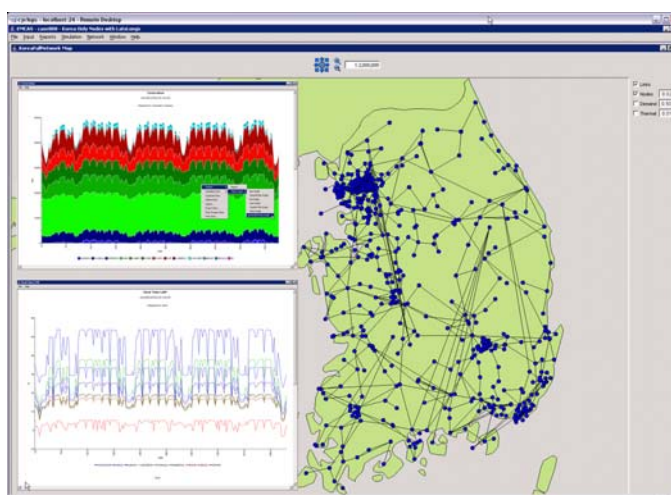
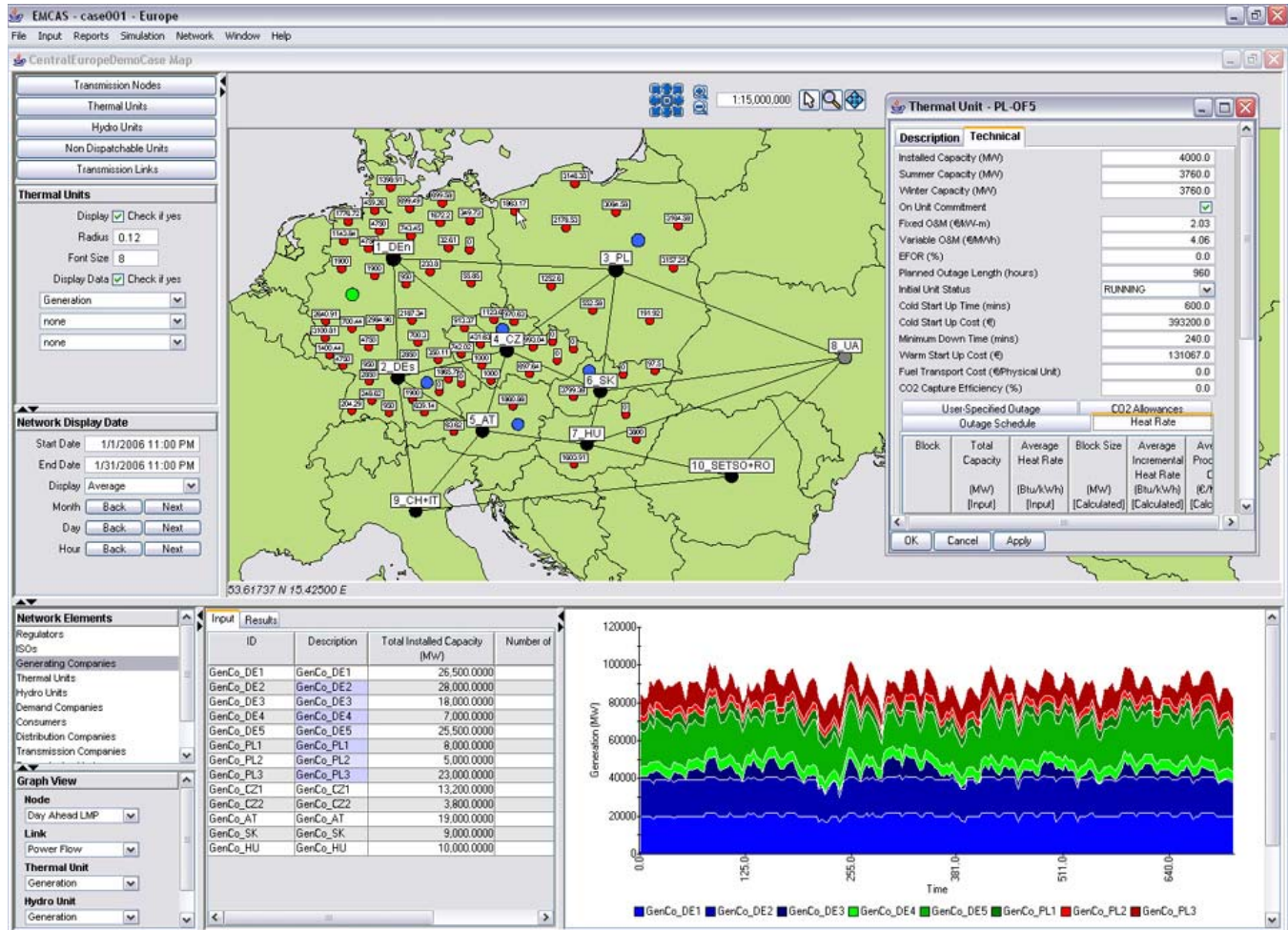
EMCAS uses a graphical user interface to develop market configurations, display model inputs, and analyze simulation results (see screen captures on next page). Results are stored in HDF format and can be exported in text and spreadsheet formats.

## Adaptability to Local Market and System Conditions

The EMCAS model is fully customizable and not hardwired to any particular system. The user builds the system configuration either within the EMCAS graphical user interface or by preparing and importing a set of well-defined input files. Network configurations can be simple and aggregate consisting of a few to several dozen



network nodes and links, or detailed bus-level representations with several thousand network elements. The level of detail largely depends on data availability and particular analysis objectives. The screen captures below show several power market representations.



## Software Features

EMCAS has the capability to simulate a day-ahead market using either a uniform or discriminatory auction format. The model also includes bilateral physical contracts. Real-time prices are calculated in a real-time dispatch using a DC optimal power flow model. A new feature added in early 2006 analyzes power system expansion issues under uncertainty. EMCAS also includes a simplified representation of ancillary services markets (no separate bidding). Some of the key strengths of the EMCAS agent-based modeling approach include:

- Represents multiple market participants (agents) with decentralized decision-making; each agent may have its own set of strategies, risk preferences, and objectives;
- Alternative company strategies can be simulated;
- Incorporates agent learning and adaptation based on performance and changing conditions;
- Market rules can be tested before they are implemented; and
- Market monitoring for price manipulation can be carried out.

## Availability of Training

An introductory course/workshop can be three days to two weeks. In a 2-week course, the first week covers the theoretical background of agent-based modeling, complex adaptive systems, and detailed EMCAS agent implementation issues. The second week continues with the theoretical background on individual software components but also offers hands-on simulations of an 11-node network with 24 generators and 8 generation company agents. A 2-week EMCAS course was recently conducted at Argonne in May 2005. The course was attended by 20 participants from 10 countries, including Argentina, Belarus, Croatia, Egypt, Hungary, Indonesia, Lithuania, Romania, Russia, and South Korea. Participants came from generation companies, research institutions, ISOs/TSOs/PXs, and regulatory offices. A similar course is scheduled for June 2006.



## Software Runtime and Hardware Requirements

A network with 10 nodes (buses or locations), 70 aggregated thermal generating units, 13 generation companies, one transmission company, one ISO, and one regulator takes approximately 60 minutes for a one-year simulation (8760 hours) on a desktop PC with a 2.0 GHz AMD Athlon2000+ processor and 1 GB of RAM. For multi-year simulations, it is recommended to use a brand-new, high-end PC, preferably with dual core processors and 2+ GB of RAM.

## Product Support

Product support is provided by staff at Argonne National Laboratory's Center for Energy, Environmental, and Economic Systems Analysis. Product support is provided on-line (NetMeeting) or via email, telephone, or site visits. Product support includes regular product maintenance as well as specific consultations or support for customization requirements.

## Demo Version

A limited Demo Version is now available. Please contact us for further details.

## References

EMCAS was first applied for a regulatory commission in the mid-western United States. At the beginning of 2005, the software became commercially available and current clients include research institutes, power companies, transmission companies, and regulatory offices in South Korea, Portugal, and Spain. The Iberian EMCAS application includes the simulation of hydropower, wind power, and a variety of other renewables.

## Price and Contact Information

The model is available via perpetual or annual site-wide licenses. For further details, please contact us at the following address:

**Guenter Conzelmann**

Center for Energy, Environmental, and Economic Systems Analysis (CEEESA)  
Decision and Information Sciences Division  
Argonne National Laboratory  
9700 S. Cass Ave, DIS/900  
Argonne, IL 60439  
(ph) 630-252-7173, (fax) 630-252-6073, (email) [guenter@anl.gov](mailto:guenter@anl.gov)